INVESTIGATION OF CLOUD PROPERTIES AND ATMOSPHERIC PROFILES WITH MODIS

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ABSTRACT

The completion of the Version 2 software delivery for MODIS has resulted in a shift of UW work priorities. Data processing has now taken precedence with the goal of tuning production algorithms and publishing results. A significant effort is underway to prepare our SCF for at launch MODIS processing. This includes the installation and testing of newly arrived SGI hardware and porting of DAAC approved software. UW personnel continue to work with MAST in the AM-1 infrared characterization of MODIS.

TASK OBJECTIVES

Software Development

Delivery of the UW science production software packages (cloud mask, cloud top properties, cloud phase, atmospheric profiles, and ancillary data) were completed in fourth quarter 1997. Further integration of the software into the DAAC processing environment involves periodic dialogue and collaboration between SDST personnel and UW. Coding continues on the production packages at the UW SCF on additions and improvements that are expected to be integrated prior to launch.

MODIS Infrared Calibration

Chris Moeller and Dan LaPorte continue to participate for UW in MODIS IR calibration activities. Both attended a MODIS infrared calibration workshop in Miami in February at which MCST reported on AM-1 calibration progress and plans for FM-1 testing. The UW also delivered regression coefficients to the MCST relating MODIS 7.34 micron (band 28) radiance and the 5.3 micron SWIR leak radiance, which were simulated using radiosondes and a forward model.

Atmosphere Group Meeting

Four members of the UW MODIS team attended the Atmosphere Group Retreat at St. Michael's Maryland on 3-5 February. The meeting was productive in reconnecting the group on science issues that had taken a back seat to software delivery requirements.

WORK ACCOMPLISHED

MODIS Software Development

Although the UW MODIS Version 2 software packages were delivered in fourth quarter 1997, several software iterations between SDST and UW personnel were necessary before the MODIS Version 2 code was baselined. Most of the iterations involved refinements to implementation of the ancillary data subroutine to adhere to PGS requirements.

Several additions and improvements to the Version 2 software are underway. It is hoped that these changes will be included in the at launch Version 2 code.

1) Addition of clear radiance maps for use in both the cloud mask and cloud top properties packages. Walter Wolf has set up a system to create the clear radiance data files for use in the Cloud Mask code (MOD_PR35). When each granule is processed in the MOD_PR35 code, a temporary clear radiance map file will be created. The pixels which are determined clear by the cloud mask are used to create this temporary clear radiance map file. These temporary files will have a resolution of 0.25 degrees in both the latitude and longitude directions around the globe (this results in 1036800 pixels). To save disk space on the operating computer, these temporary files are pseudo compressed. Each of the files will have a unique name determined by the time and date of the data along with the granule's position on the globe. At the end of the day, a program will be run to take all the temporary files and produce a global daily composite along with an updated eight day composite. The composite clear radiance files will be archived in HDF format. The method used in the version 1 code was rejected due to size, time and processing constraints. Numerous work arounds were attempted prior to Version 2 delivery, but none satisfied all SDST and DAAC requirements.

2) Addition of a high resolution near real-time global snow base map, produced by the National Snow and Ice Data Center (NSIDC) for use by EOS investigators. This data set is being tested in the daily AVHRR LAC cloud mask processing, and will be used in MODIS product generation until the cloud mask and MODIS snow mask products become stable.

3) Temporal separation of cloud top property parameters necessary for atmosphere group science investigations. Some of the atmosphere group products are produced using data from day time only. Science investigations which compare aggregated Level 3 gridded products produced from both day and night data with those produced from day only data may yield biased results.

4) Addition of the global 1 km ecosystem base map distributed by the Earth Resources Observations Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC). We are currently using a 10 minute global base map and a 1 km map over North America only.

Level 3 Software

Walter Wolf continues to work with SDST to create the atmosphere group level 3 (MOD08) output HDF product file. This work includes making modifications to the CDL file specification and to the existing C code, which reads in the file specification and creates an output FORTRAN subroutine containing all the information from the CDL file. This output FORTRAN subroutine is then used by SDST software to create the output level 3 HDF file automatically.

Visualization Software

In the first quarter of 1998, the MODIS group began producing cloud height and phase products from MAS HDF data for the first time. Since this processing was carried out entirely outside the McIDAS environment, new visualization tools were needed to display the results along with the image data. For this purpose, a new procedure was developed in IDL which permits the display of individual MAS bands, along with graphics overlays of the cloud mask, cloud height, or cloud phase results. Graphical output from this procedure was presented at the MODIS Atmosphere Group Retreat, 3-5 February, St. Michael's, Maryland. Examples of the output are shown in Figures 3 and 4.

UW MODIS SCF

Silicon Graphics Origin2000 hardware for the CIMSS MODIS SCF arrived on January 29. Components include:

- Origin2000 rack system with 2 x R10000 195MHz CPUs,
- 512 MB RAM,
- Challenge RAID with 15 x 9GB disk drives.

After an extensive testing and shakedown period, the system was made available to the CIMSS MODIS group. This system will form the core of the CIMSS MODIS SCF and will also eventually function as a CPU server for other CIMSS groups who will contribute hardware resources.

Averaging MAS to MODIS resolution

In order to assess the effects of degraded spatial resolution on MAS processing algorithms, software was developed in IDL which degrades MAS 50 meter resolution data to approximate MODIS resolution (1000 meter). To simplify processing and visualization of results, the program creates an output HDF file in exactly the same format as the input file, except that all image arrays are averaged to 1000 meter resolution and the resulting average values are replicated to give the same number of pixels and scans as the input file. This allows existing processing and visualization software to be used without modification to process the data.

Atmosphere Group Meeting

Steve Ackerman, Rich Frey, Liam Gumley and Kathy Strabala attended the MODIS Atmosphere Group Retreat on 3-5 February in St. Michael's Maryland. Many group issues were discussed, including algorithm progress, outstanding concerns and group science investigations. UW algorithm status was presented for each product using results from SUCCESS and WINCE data. Critiques of the MAS cloud mask were given by the teams headed by Dr. Michael King and Dr. Yoram Kaufman. They used output from the cloud mask as input to the cloud optical properties and aerosol algorithms. The critique and ensuing discussion was of great use; it helped to identify problem areas and gave us a better understanding of how the MODIS cloud mask will be used operationally.

MODIS Infrared Calibration

Chris Moeller and Dan LaPorte attended the MODIS IR calibration workshop held on 2-3 February in Miami. At the meeting MCST updated the group on progress of MODIS AM-1 IR calibration characterization as well as plans for FM-1 testing. Considerable progress has been made in characterizing MODIS IR calibration. MODIS RSR has been finalized, separate calibration for each scan mirror side was agreed upon, and the form of the PC band crosstalk correction algorithm has been accepted. Further investigation is planned for PC band crosstalk correction coefficients for PFM, aft optics polarization effects in PFM and measurement in FM-1, destriping techniques for earth view data, and ADC nonlinearity correction. BCS to OBC calibration transfer is progressing. The development of the Thermal Emissive Band (TEB) calibration algorithm is on schedule for readiness when initial MODIS global data sets are collected (about two months after launch).

During the MODIS calibration workshop, it was suggested that UW investigate the feasibility of using the Fourier Transform Spectrometer (FTS) method for MODIS RSR measurements. The FTS method is now being applied for MAS RSR measurements (see MAS Calibration section below). While MODIS data timing and collection scheduling issues are not yet resolved, it does look like the FTS equipment costs will be under 200 K and optical matching with MODIS is feasible. We are suggesting that SBRS be authorized to proceed with a small study effort needed to resolve the data timing and schedule issues, and to develop a cost estimate for data collection, test time, and optical matching equipment.

A revised set of BCS temperature settings have been forwarded to MCST for use during FM-1 T/V performance testing. A temperature setting at 200 K was added to supplement atmospheric band characterization, and the temperature spacing between settings was adjusted to be approximately uniform in radiance space. These settings with minor revision were accepted by MCST and will be applied to the FM-1 performance data collection scheduled for June timeframe.

Regression coefficients relating radiance of MODIS band 28 (7.34µm) and the SWIR leak region at about 5.3µm have been delivered to MCST. The relationship (Figure 1) predicts the radiance at 5.3µm as a function of MODIS band 28 radiance for input to correct radiance leakage into MODIS SWIR bands 5, 6, 7, and 26. The relationship is based on one year of global radiosondes used in a forward model based on MODIS RSR and the MODIS Airborne Simulator (MAS) spectral band at about 5.25µm. While the relationship is a very good predictor for the majority of atmospheric conditions encountered by MODIS, it will be challenged when MODIS is viewing very dry atmospheric conditions over variant surface emission conditions. This relationship will be implemented for use at launch but is expected to be updated by on orbit SWIR band measurements in nighttime conditions.

MAS Calibration

Wisconsin and Ames Research Center (ARC) atmospherically corrected monochromator measurements of the MAS IR spectral response functions (SRF) from February 1997 have been compared using forward model calculations. Both Wisconsin and ARC use the same approach to atmospherically and spectrally correct the raw SRF measurements; however, truncation and smoothing differences are causing some variation between the Wisconsin and ARC corrected (i.e., "final") SRF. The comparison (Table 1) shows that differences in most MAS bands are less than 1% ($\Delta L/L$), with exception of bands 35 (MWIR CO_2 band), 40 and 41 (H_2O sensitive bands). Radiometric differences in bands 32, 35, 47 and 50 are primarily due to retention of SRF data in the "wings" of the band while differences in bands 39-41 are primarily caused by difference in the shape of the final SRF. A detailed review of the Wisconsin and ARC SRF correction procedures will be made to remove any artifacts of the correction procedure in the final SRF.

ARC has implemented a standard procedure for spectrally calibrating the MAS instrument. This includes a spectral alignment of the four ports (VIS/NIR, SWIR, MWIR, LWIR) of MAS before every field deployment as well as the standard spectral measurement before and after each deployment. The benefit of this approach is that it "standardizes" MAS spectral characteristics going into every field deployment, and thus allows a rapid turnaround of "preliminary" calibrated data after the deployment (within weeks instead of months). The increasing use of FTS technology in the ARC calibration facility has dramatically reduced the data collection time for spectral alignment and calibration to about 1/3 of that required by the monochromator measuring system.

Fourier Transform Spectrometer (FTS) measurements of MAS SRF at the ARC calibration facility are being evaluated in a research mode as a possible replacement for the traditional monochromator-based approach. Currently, both FTS and monochromator based spectral measurements are being made. The FTS system has the advantages of comprehensive spectral coverage (400 - 4000 cm^{-1}) for each measurement, improved signal to noise and spectral resolution compared to the monochromator system, and requires less time to collect the data. The comprehensive spectral coverage facilitates identification of out-of-band response in each spectral band while improved signal to noise and spectral resolution enhance definition of spectral absorption features. MAS spectral measurements using FTS were compared to monochromator measurements using data collected in February 1997. The comparison is made by simulating MAS radiances (using forward model) for the FTS and monochromator SRF. HIS data is used to define the earth-atmosphere radiance spectrum for the forward model. The simulated MAS radiances are then compared with collocated MAS inflight radiances to determine absolute calibration biases between MAS and HIS for each set of SRF. Because of enhanced spectral feature definition using the FTS system (leading to a better atmospheric correction), it was expected that FTS would improve the accuracy of MAS SRF for atmospheric bands; however, findings show that using FTS for MAS SRF measurements did not reduce absolute calibration biases between MAS and HIS for the atmospheric bands (e.g. bands 33, 34, 43, 49, 50 in Table 2). The implications of this unexpected result include possible unanticipated spectral shift of the MAS grating position sometime between the dates of February 8 and the monochromator and FTS measurements (taken a few days apart in late February), erroneous SRF measurement by the FTS system, or inaccurate atmospheric and spectral correction of the FTS measurements. Subsequent MAS spectral characterization by FTS has been made and will be evaluated in a similar manner.

In February, a paper titled "Spectral characterization of MODIS Airborne Simulator (MAS) using an interferometer as a source" was presented to a Bomem FTS workshop held in Quebec City in February. The paper recounted the experience of ARC in applying FTS technology to making spectral measurements of the MAS instrument. While FTS usage for spectral calibration measurements is still in a maturing process, the paper outlined the benefits of applying FTS, which include simultaneous measurement of in-band and out-of-band response, improved signal-to-noise and improved spectral resolution, all with significant reduction in laboratory measurement time required.

<u>MAS Participation in CAMEX-3</u>

Despite a delay in the launch of EOS AM-1, MAS will be deployed on the ER-2 during the final two weeks (tentatively Sept 10-24) of CAMEX-3 (to be held in Aug/Sep 1998 from Patrick AFB, FL). The science interest in underflying MODIS on AM-1 will shift to underflying NOAA-K (launch in May 1998). NOAA-K carries the new AMSU-A and AMSU-B instruments as well as infrared sounding capability. The performance of these instruments will be validated by ER-2 underflight in conjunction with surface based observations (uplooking lidar, uplooking and downlooking interferometers). CAMEX-3 also presents opportunities to monitor clouds (microphysics, heights, detection) in tropical systems with co-incident in situ data collection. The ER-2 will be equipped with a dropsonde capability for characterizing the atmosphere below the aircraft. MAS will contribute quicklook imagery and nadir brightness temperatures for selected bands as well as derived cloud products from case studies of interest to the CAMEX-3 archive.

The NPOESS Airborne Sounder Testbed - Interferometer (NAST-I) instrument has been delivered to Dryden Flight Research Center (DFRC) for integration on the ER-2. NAST-I will fly during CAMEX-3 and is an important component of MODIS calibration validation activities. Two instrument checkout flights were conducted from DRFC; NAST-I successfully interfaced with the ER-2 platform on these flights. The checkout is to be followed by one or more short science calibration missions as a piggyback on other associated ER-2 missions. It is anticipated that these flights will occur early in the next quarter.

AVHRR Cloud Mask Web Site

An additional feature has been added to the display of AVHRR near-real time cloud mask results at http://cimss.ssec.wisc.edu/poes/cldmsk.html. Images of NDVI (Normalized Difference Vegetation Index) are shown for clear-sky regions in portions of North and South America. In addition, weekly averages are shown for most of North and Central America which will track the changes in the amount of green vegetation with time as the seasons progress from late winter through spring and into summer. Also seen are the changes in parts of Central America due to the transition from the dry to the wet season. The intent is to show an example of a practical benefit of the cloud mask and not to indicate quantitative vegetation index results.

Infrared Surface Emissivity Studies

Visiting scientist Dr. Youri Plokhenko continues his investigation of MAS temperature/moisture retrieval sensitivity to surface emissivity. He is using a physical retrieval algorithm to evaluate atmospheric temperature and humidity, and surface emissivity. Good correlations between retrieved surface temperature derived using a non-uniform emissivity (reflection included) and the Normalized Difference Vegetation Index (NDVI) are found (Figure 2). The statistically significant negative correlation (-0.78) can be physically explained by an increase in vegetation density corresponding to a decrease in temperature through evapotranspiration. The scatter diagram in Figure 2 demonstrates that the surface temperature estimate obtained by the model, which includes reflection, is physically grounded.

Radiative Transfer Through Cirrus Clouds

Dr. Sunggi Chung continues calculating the cloud forcing expected from various cirrus cloud formations. Using line by line code (LBLRTM) in combination with a discrete ordinate model (DISORT), ice particles of various sizes, water paths, and heights have been inserted into a clear sky atmosphere to investigate the spectral characteristics of the cloud forcing. Comparisons of these calculations to interferometer measurements in various cloud situations have enabled estimation of cloud particle size and ice water path. This past quarter he has been testing sensitivity of the inferred cloud properties (particle size and ice water path) to hidden clouds (multilayer cloud situations) and incorrect estimation of cloud height. He will present a paper on this work at the Conference on the Atmospheric Effects of Aviation held the week of 27 April in Virginia Beach, VA.

DATA ANALYSIS

MAS CO_2-Slicing Algorithm Development

Work continues on the CO_2-slicing algorithm as applied to MAS data. An improvement has been made to the method when retrieving cloud pressure altitudes of low clouds. It was noticed that some unrealistically high cloud altitudes were obtained when the scene included low-level water clouds. These results were due to the 11/13 μm channel combination being inappropriately utilized for water clouds which have differing cloud emissivities at these two wavelengths. A check on the difference between the 8 and 11 μm brightness temperatures can provide a way to make sure the scene contains only ice cloud. If the 8 - 11 μm brightness temperature difference is less than 2 degrees, the 11/13 μm cloud height solution will not be used. The same change will be made to the MODIS algorithm.

Algorithm Development and Testing

Completion of the UW MODIS production software deliveries has permitted the UW group to concentrate on science data processing and algorithm testing. Both the cloud phase and cloud top properties algorithms have been revised to use the MAS HDF cloud mask product as input. Scenes from both WINCE and SUCCESS are being used in the analyses. One scene that is being examined carefully is the MAS SUCCESS flight segment #28 (21:36:48 - 21:41:01 UTC) from 2 May 1996. Wave clouds, isolated cumulus clouds and even contrails can be observed in the scene. This segment is of particular interest due to the availability of validation data from both the ER-2 CLS and the DC-8 microphysical instruments. Wave clouds formed over the Colorado Rockies this day due to strong Northwest flow at 500 hPa. The DC-8 and ER-2 aircraft were deployed on a mission to fly stacked patterns over and through the wave clouds.

Wave clouds are clearly evident as cold cloud with diffuse edges in the 11 micron image (Figure 3, left panel). A narrow contrail is apparent across the top of the image horizontally. Another contrail is faintly visible entering the large wave cloud from the top right part of the image. This is the trail of the DC-8, which is actually sampling within the cloud during this ER-2 overpass.

The MAS versions of the MODIS cloud mask, cloud top property and cloud infrared phase algorithms were applied to the selected track. Both the cloud top property and cloud phase algorithms used results from the cloud mask to decide when they would be implemented. Each performed retrievals on a 10 x 10 pixel region. If more than 20 of the pixels were flagged as uncertain or cloudy by the cloud mask, then the radiances of the 10 x 10 box were averaged (to reduce noise) and a retrieval was made. The three center panels of Figure 3 show results from the cloud mask and cloud top properties overlaid on the 11 micron brightness temperature image. Shaded regions in the cloud mask panel indicate pixels which were identified as uncertain or cloudy. The mask is of good quality when compared with the 11 micron image. All parts of the wave cloud, cumulus and contrails are flagged as cloudy. Certain land features in the middle left portion of the scene are flagged as cloudy; these are bright landmarks flagged as cloud by the visible reflectance tests. Work is underway to determine if these features will cause failures in the mask at the nominal MODIS 1 km resolution.

MAS CO_2 cloud top pressures and effective cloud amounts for the May 2 flight track are shown in the right image panels of Figure 3. Wave cloud top pressure retrievals consistently lie between 200 and 300 hPa, except near the top edge of the large wave cloud, where the tops lower to 300-400 hPa. Effective cloud amounts (or effective emissivities) range from very small around the edges of the wave clouds (10-20 %) to large (80-90 %) in the center of the clouds. Cloud amounts of 100 and cloud heights of 800 hPa dotting the edges of the clouds and in the contrail are due to the window channel solution default in areas where the cloud forcing is too small (within instrument noise). When the 10 x 10 pixels area is averaged, these very thin clouds will have a very similar radiance as that of the calculated clear values. To solve this problem, the MODIS version will not allow the window channel solution to be used unless all pixels in a given box are flagged as cloudy. Cumulus cloud retrievals are generally as expected, with cloud heights lower and cloud amounts greater than the wave clouds.

The rightmost panel of Figure 3 is a graph of nadir cloud heights from both the ER-2 Cloud Lidar System (CLS) and MAS CO_2 slicing. The CLS algorithm detects a maximum of five cloud top and cloud bottom altitudes based upon the backscatter signal. In the graph, the highest two detected cloud tops are plotted. The different techniques compare favorably over much of the scene. There are stretches however, where the cloud mask did not detect cloud, but the CLS was detecting very thin cirrus. Both techniques retrieve cloud heights for most of the wave clouds at 12 km. The main exception is near the end of the track, where the CO_2 heights drop. In this case, a second, and even third and fourth cloud deck is found (not shown). In multi-layer cloud layer situations, the CO_2 slicing technique will calculate a cloud top pressure in between the top and bottom layer.

Validation of the MAS cloud top pressures is underway using the CLS instrument. An automated technique to compare the cloud top pressure retrievals has been tested, and will be run on all collocated MAS and CLS SUCCESS scenes.

Cloud phase retrievals from this track were generated for MAS viewing angles less than 20 degrees. The results are shown in Figure 4. The quality of the results are mixed. The majority of the wave clouds, which are high and cold and composed of small ice crystals, are flagged as either thin or thick ice cloud (values 4 and 2 in Figure 4). As you proceed towards the edge of the wave clouds, the technique flags pixels as either mixed phase (3) or non-opaque water cloud (5). The reason for this is that no good linear fit was made to 8 minus 11 micron versus 11 minus 12 micron brightness temperature differences. As a result, the technique defaults to a pixel by pixel cloud phase discrimination. Ambiguities in the scatter diagram for thin cirrus and water cloud cause misidentifications. Work continues on ways to improve phase determinations in mixed-phase and multi-layer cloud situations.

Efforts to validate MODIS products using the MAS continue. In addition to the previously mentioned CLS validation work for the cloud top pressure and cloud mask products, UW personnel are also pursuing the use of DC-8 microphysical instruments to validate cloud phase and infrared cloud particle size retrievals. Dr. Andrew Heymsfield visited UW on March 16, to outline a collaborative effort between Colorado and UW.

MODIS Infrared Calibration

(1) At the February MODIS IR calibration workshop, PFM PC band crosstalk was discussed with a goal of identifying an acceptable correction algorithm for use in the MODIS L1B data production software. The analysis of correction coefficients for use in the correction algorithm was also discussed. Data analysis indicates that a linear correction approach is acceptable. The proposed correction algorithm makes the correction at the digital number (DN) level of the calibration process. Importantly, DN must be corrected for all scenes (EV, SVP, BB). The proposed algorithm is

$$DN^{true}(i,j) = DN^{cont}(i,j) - Xtalk * DN(31,j) *p(i,j) + q(i,j) \qquad (1)$$

where DN^{true} and DN^{cont} are the non-crosstalk affected DN and the crosstalk contaminated DN respectively for band i channel j, Xtalk is the crosstalk amplitude from band 31 channel j to band i channel j, DN(31,j) is the DN for band 31 channel j, and p and q are placeholders for post-launch adjustments to the algorithm (set to 1.0 and 0 resp. at launch). The spatial dependence of the crosstalk from the band 31 leak source and the receiving band i is not expressly shown in eqn (1) but is included in the correction algorithm.

An approach using the PFM RC-02 radiometric performance test data sets has not been successful in uniquely retrieving the value of Xtalk for each PC band, but has contributed towards formulating the correction algorithm and gaining insight into PC band crosstalk effects on performance test data. For example, the pre-launch PC band radiometric calibration coefficients will be adjusted to remove influence of PC band crosstalk on them. A new approach for identifying the value of Xtalk for each band has been proposed by MCST. This physical approach is based on the expectation that same-family detectors should exhibit very similar nonlinearities. Preliminary findings are in line with anticipated crosstalk amplitudes of the various PC bands based on analysis and experience with other PFM test data sets. The assumption of similar nonlinearities in same family detectors will be tested by analyzing data from FM-1 performance tests; PC band crosstalk in FM-1 is expected to be small compared to that of PFM.

Consideration of how PC band crosstalk amplitude can be determined on-orbit has focused on the use of moon view data. MODIS will view the moon in its various phases on a regular basis (approximately monthly) through the SVP. That data will be used in a regression analysis of the Xtalk coefficient through applying a rearranged eqn (1) to scenes in which DN^{true} is constant (i.e., when DN^{true} is the deep space background).

Because of the spatial dependence of PC band crosstalk, it is anticipated that band 31 will be illuminated by the moon when other PC bands are viewing cold space. Two data points (one of band 31 on the moon and one of band 31 viewing deep space) can be used to solve the linear system for the Xtalk coefficient as the slope of DN(31,j) versus DN(i,j). By performing this exercise on a regular basis, a timeseries of Xtalk estimates will be produced and reviewed for stability. These Xtalk estimates can be applied, initially on a trial basis, in the L1B radiance algorithm and evaluated. Through concerted effort, an improved crosstalk correction will be sought. Other methodologies, including large data samples of earth view scenes, are under consideration.

2) A small radiance leakage from band 27 into band 28 on PFM is being assessed. The leakage was depicted in spatial performance test data (UAID 1194). A simulation of band 27 and 28 radiance with leakage showed that if the leak amplitude exceeds 2% (relative to band 27 inband response), it eclipses the 1% absolute radiometric requirement in band 28. Spatial performance test data approximates the leak amplitude to be less than 1% relative to band 27 inband response.

PAPERS

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MEETINGS

Chris Moeller and Dan LaPorte attended the MODIS IR Calibration Workshop held on 2-3 February in Miami, FL.

Steve Ackerman, Liam Gumley, Rich Frey and Kathy Strabala participated in the MODIS Atmosphere Group Retreat held on 3-5 February in St. Michael’s Maryland.

Table 1. Comparison of UW and ARC processed SRF for IR bands.

band No.	Wavelength (μm)	L_{ARC} (W/m2 sr μm)	L_{UW} (W/m2 sr μm)	ΔL (W/m2 sr μm)	ΔL / L (%)	ΔT (K)
27	3.26	0.0636	0.0636	8E-05	0.13	0.08
28	3.41	0.1584	0.1596	-0.0012	0.78	-0.08
29	3.57	0.2861	0.2868	-0.0008	0.27	0.03
30	3.73	0.4160	0.4177	-0.0016	0.39	-0.03
31	3.88	0.5616	0.5639	-0.0024	0.42	-0.04
32	4.05	0.6922	0.6988	-0.0066	0.95	-0.23
33	4.20	0.3279	0.3279	-1E-05	0.00	-0.01
34	4.36	0.0824	0.0824	-1E-05	0.01	0.02
35	4.52	0.5366	0.5563	-0.0197	3.68	-0.75
36	4.67	1.3781	1.3840	-0.0059	0.43	-0.02
37	4.83	1.4341	1.4384	-0.0043	0.30	-0.02
38	4.98	1.6230	1.6288	-0.0058	0.36	-0.09
39	5.14	1.4331	1.4433	-0.0102	0.71	-0.17
40	5.28	1.2570	1.2736	-0.0166	1.32	-0.28
41	5.40	1.1526	1.1782	-0.0256	2.22	-0.59
42	8.52	8.7376	8.7491	-0.0115	0.13	0.03
43	9.71	6.2289	6.2282	0.0007	0.01	0.02
44	10.50	9.5350	9.5386	-0.0036	0.04	-0.05
45	11.00	9.3618	9.3534	0.0084	0.09	-0.02
46	11.99	8.6394	8.6190	0.0204	0.24	0.03
47	12.88	7.5146	7.5358	-0.0212	0.28	-0.23
48	13.28	6.1700	6.1730	-0.0030	0.05	-0.04
49	13.81	4.0881	4.0837	0.0044	0.11	0.07
50	14.26	2.6642	2.6547	0.0095	0.36	0.19

Table 2. MAS-HIS biases based on monochromator and FTS SRF. Only bands for which commensurate HIS radiance data is available are shown. Simulated MAS radiances (convoluted MAS SRF with HIS radiance spectra) were compared to collocated MAS observations using clear sky data scenes over Lake Huron on 8 Feb 1997. The monochromator based and FTS based biases are small and comparable for window bands (e.g. bands 31, 44, 45); spectral sensitivity in window bands is small. The more spectrally sensitive atmospheric band biases are larger for FTS than monochromator based SRF (e.g. bands 33, 34, 43, 50). This suggests that the quality of the Feb 1997 FTS based SRF may be lower than the monochromator based SRF.

MAS Band	Wavelength (μm)	MAS scene temp (K)	HIS scene temp (K)	MAS-HIS bias monochromator (K)	MAS-HIS bias FTS (K)
30	3.73	273.61	269.76	3.85	4.41
31	3.88	272.36	273.29	-0.93	-0.92
32	4.05	269.85	270.98	-1.12	-1.73
33	4.20	248.70	249.27	-0.58	-2.97
34	4.36	227.09	225.80	1.29	3.76
35	4.52	253.38	254.74	-1.36	1.48
36	4.67	269.20	270.09	-0.90	-1.35
37	4.83	267.82	268.61	-0.79	-0.46
42	8.52	272.23	272.65	-0.42	-0.44
43	9.71	258.30	257.96	0.33	1.69
44	10.50	273.81	274.01	-0.20	-0.19
45	11.00	273.86	273.99	-0.13	-0.15
46	11.99	273.49	273.52	-0.03	-0.04
47	12.88	271.20	271.24	-0.04	-0.19
48	13.28	262.13	262.22	-0.09	0.12
49	13.81	243.67	242.29	1.38	1.45
50	14.26	225.44	223.74	1.70	2.95

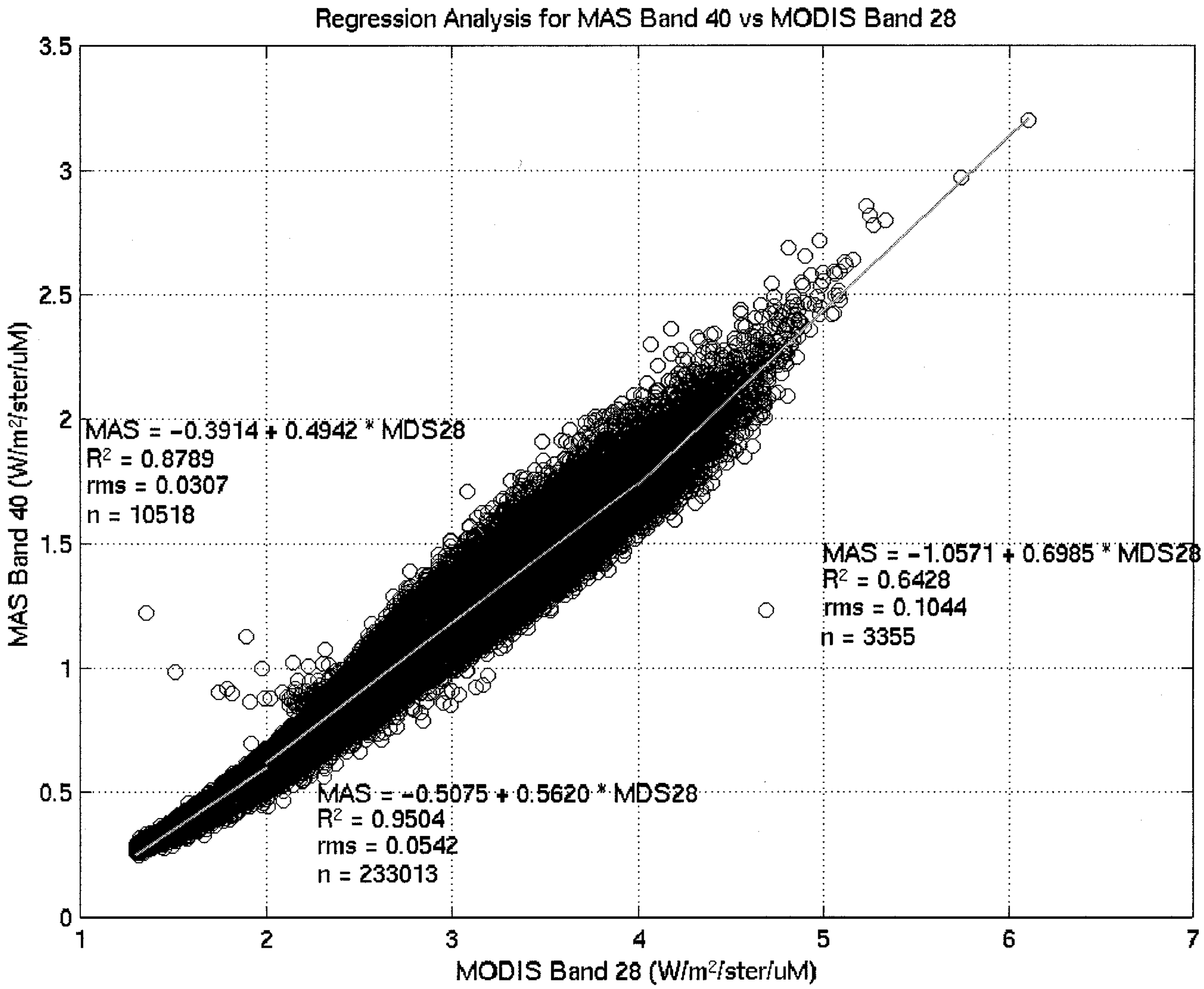

Figure 1. Relationship between MODIS band 28 and 5.3µm radiance as represented by MAS band 40. The data used in the chart are simulated radiances for one year of global radiosonde data. Very cold to very warm conditions are represented in the global sample. Separate regressions will be used for cold, moderate, and warm scene temperatures.

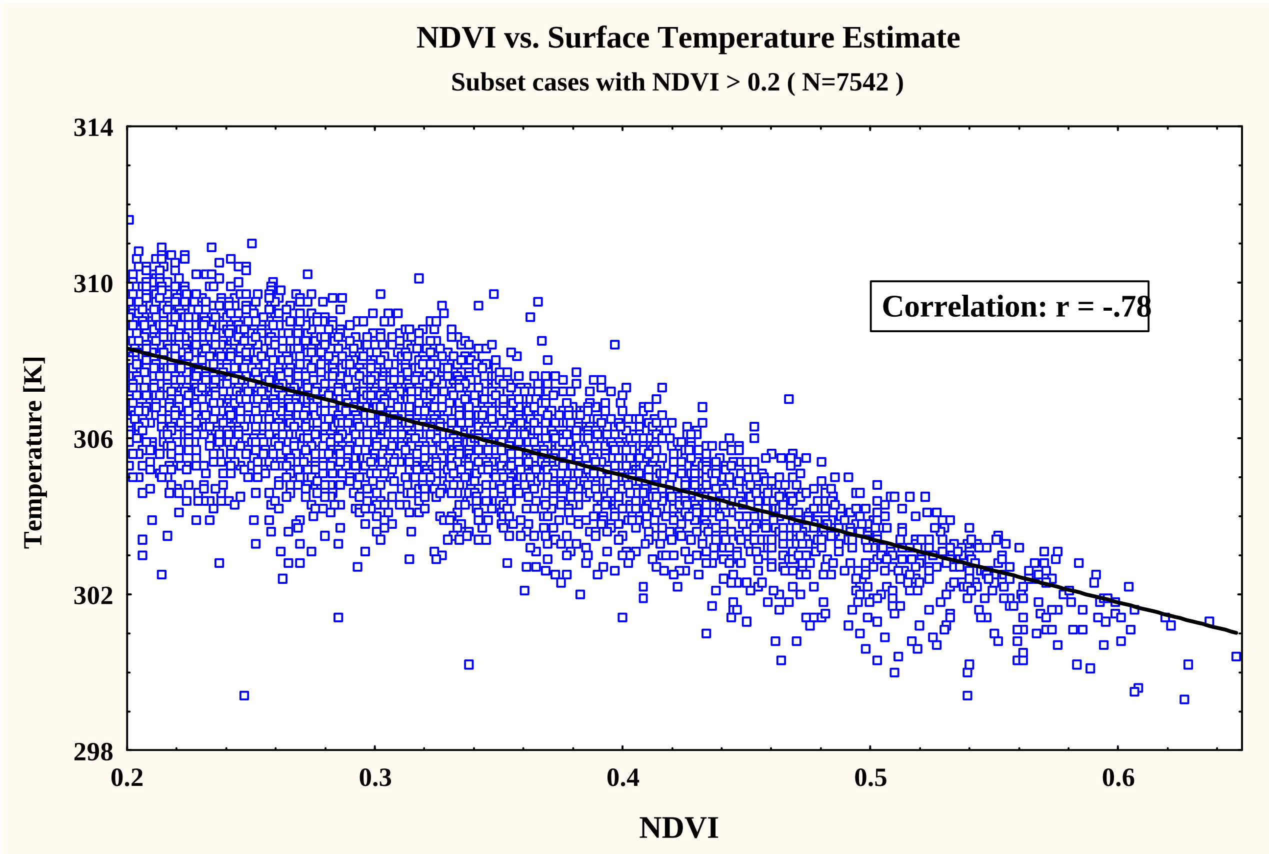

Figure 2. Scatter diagram of retrieved surface temperature, which includes surface reflection, versus the Normalized Difference Vegetation Index (NDVI) derived from a MAS SUCCESS flight from 13 April 1996.

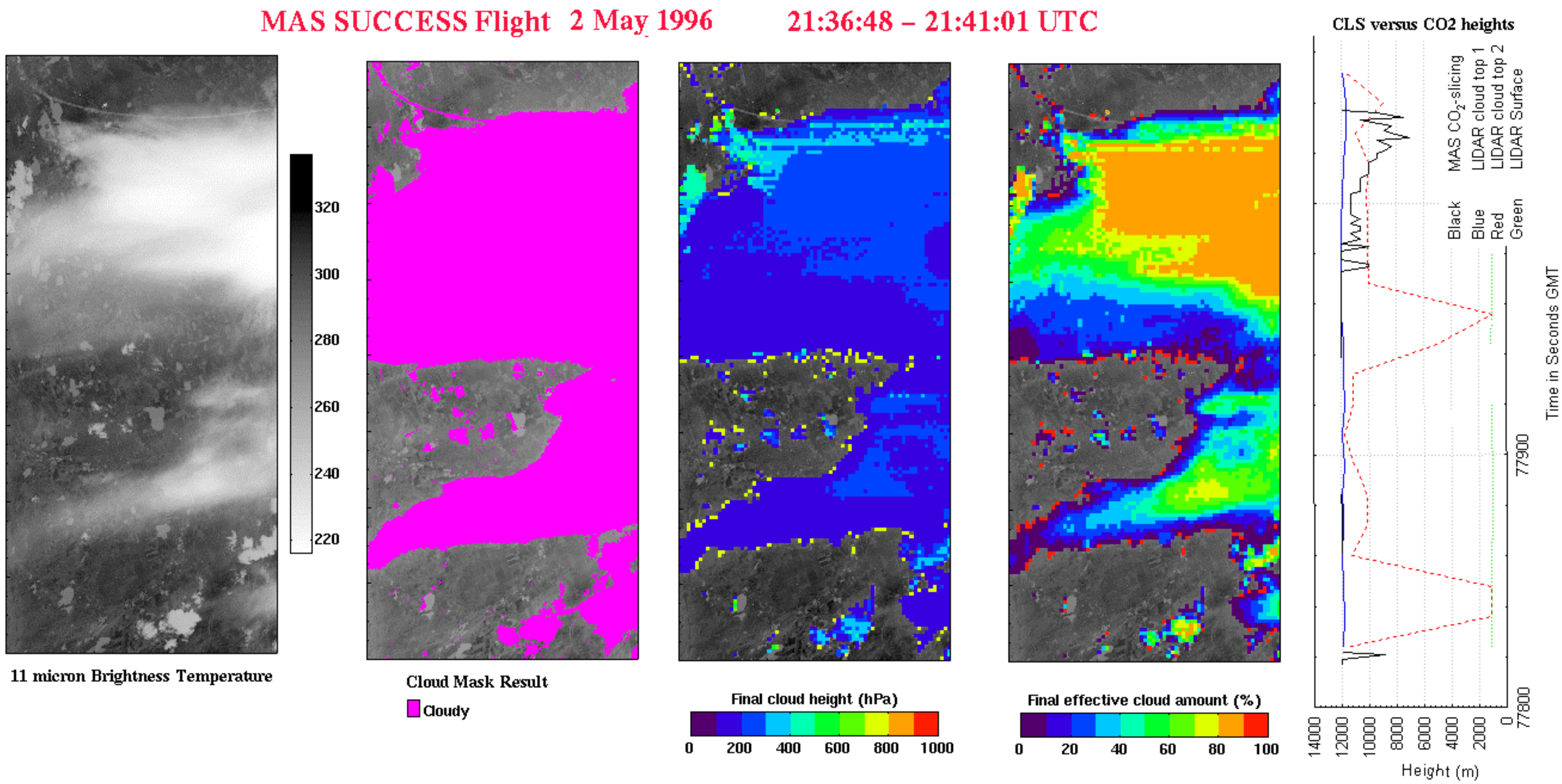

Figure 3. Example of the UW MODIS algorithm testing using MAS data, including validation. The leftmost panel is an 11 micron image including temperature scale. The middle three image panels are product results (cloud mask, cloud top pressure and cloud effective cloud amount) retrieved from the scene. The rightmost panel shows a comparison of cloud height retrievals between the MAS and Cloud Lidar System (CLS) onboard the ER-2.

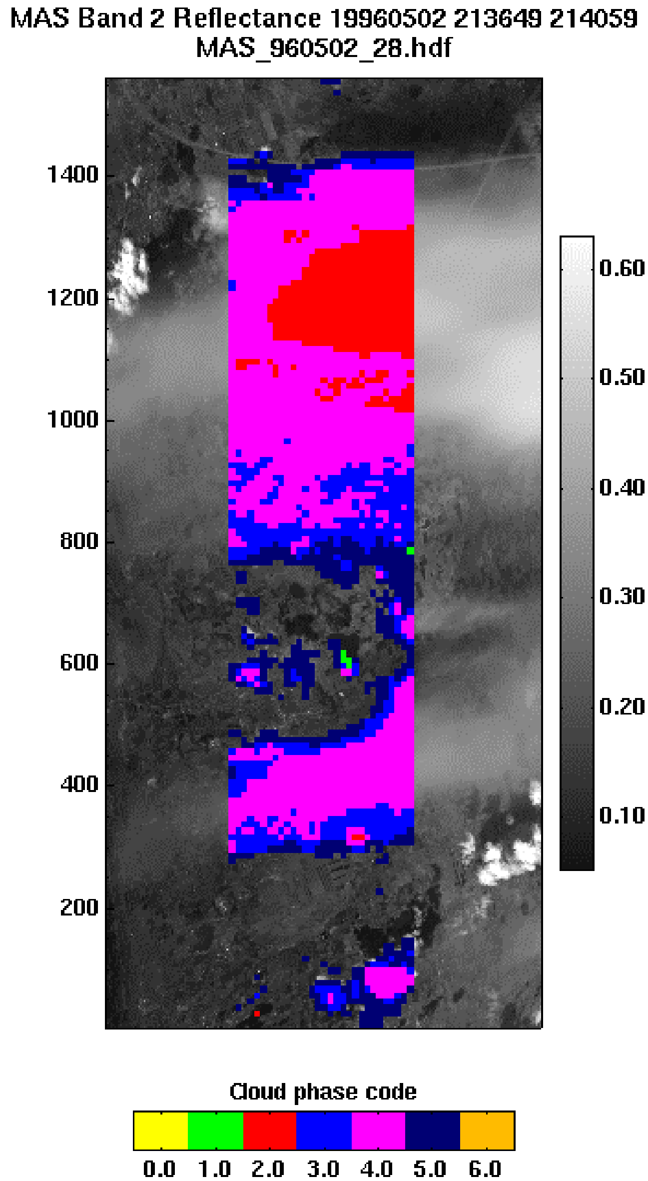

Figure 4. Results of the MAS cloud phase algorithm when applied to the same scene as shown in Figure 3. The cloud phase code stands for: 1) opaque water cloud 2) opaque ice cloud 3) mixed phase cloud 4) thin ice cloud 5) thin water cloud 6) uncertain.